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Algal periodicity in certain ponds and streams

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It is a matter of common observation that algal growths may suddenly appear in ponds and streams, persist for a short time, then disappear with equal suddenness. Doubtless many have noticed this in a casual way and wondered why the plant appeared so suddenly, or why it disappeared. In order to answer these questions, or to form even a good opinion of the causes underlying this irregularity, one must study the algal growth in a certain pond or stream at frequent intervals throughout a year or more, noting the different species of algae present, their relative abundance, time of fruiting, etc., and all the external conditions under which the plants are growing at any particular time. These conditions will include amount of light, depth and extent of the body of water, rate of flow and change of water, temperature, amount of mineral matter in the water, cormophytic growth, animal life in the water, and any effect man may have had, as in draining ponds, emptying rubbish, or sewage, etc., into the water.

But little careful and systematic study has been devoted to this subject. Fritsch * ('06) has given the subject some study. In his paper he makes some good suggestions in regard to methods and gives some interesting observations based on a somewhat irregular study.

During April, 1906, the writer began the study of the algae in a small stream flowing across the campus of Indiana University, and in two ponds near Bloomington. This observation extended throughout April, May, and June, 1906. The following

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* Fritsch, F. E. Problems in aquatic biology with special reference to the study of algal periodicity. The New Phytologist 5: 150–169. Jl 1906.

[The BULLETIN for April, 1908 (35: 155–222. *pl. 6–10*) was issued 29 Ap 1908.]

September the work was again taken up, additional ponds and streams added to the number under observation, and continued until August, 1907. Collections were made twice a month, material being taken from several different parts of each pond or stream, both on the surface and on the bottom, placed in separate vials, and brought to the laboratory for identification. This was done to avoid error so far as possible in determining the amount of any particular alga present. In nearly every case when an alga was found in any quantity in one part of a pond, it was found in other parts also.

It was thought best to select a limited number of ponds and streams and study these closely. The ones chosen were selected on account of the variety of conditions they presented and the ease with which they might be reached. Five different ponds and two small streams were under observation. The ponds will be designated as ponds nos. 1, 2, 3, 4, and 5, and the streams as streams nos. 1 and 2.

Pond no. 1 is a small body of water in an old sink-hole depression, the bottom of which has become clogged and partly filled with soil. It is about 40 feet across and 4 feet deep during the greater part of the year. During August and September the water becomes low, leaving the bottom bare in places. The pond is fed mainly by underground water flowing through openings in the limestone, which is near the surface in this region. The depth of the water varies with the season but is not much affected by a single rain. A small amount of surface water flows into it, carrying in some red clay from the surrounding plowed field. The water must be changed frequently, for it never seems to be impure. The pond is on a hill in an open field, so there is no shade. On November 10, there were .006 g. of solid matter in 54 g. of the water, or 00011 per cent. of the water was solid matter. *Typha*, *Alisma*, *Eleocharis*, *Potamogeton*, and *Callitriche* grow in the pond rather abundantly, but the animal life is not very extensive, consisting of a few salamanders, frogs, tadpoles, dragon-fly larvae, and a few smaller forms.

Pond no. 2 is a small, shallow pond, about two feet deep and 50 feet wide, fed by a spring near by. This pond is not subject to much variation in depth of water. The flow from the spring is sufficient to change the water in a day or so, but since the spillway is just opposite the feedway and the pond is wide compared with its depth, the water is not changed frequently enough to keep it very pure. A drove of cows run to the pond; this adds to the impurities. On October 29 the amount of mineral matter in the water was .013 g. in 42 g. water or .0003 per cent. The pond is in the open, so is not shaded in any way. But few of the higher plants grow here, a few specimens of *Eleocharis* and *Alisma;* a few frogs and tadpoles are found in the pond the greater part of the year and some small catfish and sunfish.

Pond no. 3 is a small body of water about 30 feet by 50 and two feet deep. It is fed by a wet-weather branch during the greater part of the year. During July, August, and September, the pond goes almost dry. The water is not changed very frequently, hence becomes stagnant. It is not shaded. *Eleocharis* plants grow in tufts over a part of the pond, especially when the water is low. On December 17 the water contained .0003 per cent. mineral matter.

Pond no. 4 is a body of water covering three or four acres and is about 20 feet deep in deepest part. It is formed by a levee built across a small valley and is fed by a small stream. The water is comparatively pure and clear. It overflows but occasionally. On November 3, there were .011 g. of solid matter in 40 g. water or .00027 per cent. The pond is practically free from animal life; it has but few of the higher plants growing in it and there is but very scant vegetation on the surrounding hillsides, hence it is not shaded.

Pond no. 5, or the water-works reservoir, consists of two large bodies of water fed by several springs. Each covers several acres and is from 10 to 20 feet deep. During late summer and in the fall the water becomes low, but on the whole the depth of the water is not subject to much variation. The water is pure and clear the greater part of the time. There are very few cormophytes growing in these bodies of water, but there are forests on three sides of one and on two sides of the other. Hence they are somewhat shaded along the edges and humus from the woods is washed down into the ponds, the sloping banks being made rich. On October 17 the water contained .00021 per cent. solid matter. Animal life in the ponds is scant — only a few fish.

Stream no. 1 is a small stream that flows across the University campus. Above the campus it has the characteristics of an ordinary small stream flowing across the country. During the greater part of the year this flows briskly with a considerable volume of comparatively pure water. After the stream enters the campus it is greatly changed. It receives the warm water from the bathing rooms, the refuse from the chemical laboratories, and the sewage from the closets in the university buildings. This part flows the whole year. The conditions of the two parts of this stream being so radically different, it may be considered as two different streams. This stream is shaded but little, has grassy banks, and and but few of the higher plants grow in it. A few frogs are found here, snapping turtles, mancelli, and planarian worms. On October 31 the water in the stream above the campus contained .015 g. solid matter in 40 g. of water, or .0037 per cent.

Stream no. 2 is a small stream of cool, clear, pure water flowing through a wooded valley about one fourth of a mile long. It is fed by the outflow of an underground river. The flow of the stream is rapid and continues throughout the year without much variation, the temperature being very uniform, standing about 12° C. The plant life, aside from the algae, is limited to an aquatic *Porella*, and the only animals found here are a few fish, crayfish, gammari, and planarian worms.

Of all the orders of algae found growing in the ponds and streams under observation the order Conjugatae was the most abundant both in quantity and in distribution. Among the forms of this order, *Spirogyra* was the most abundant. It was found in some quantity in all the ponds and streams except in the pond no. 1.

Several different species of *Spirogyra* were found. However, it was often difficult to determine the species when in vegetative state. But several of the most common forms were seen fruiting at some period. In that stage they could be easily identified. *Spirogyra nitida* was the most abundant form throughout the year, appearing in considerable quantity in all the ponds and streams except ponds nos. 1 and 5 and stream no. 2. This species was most abundant throughout the year in pond no. 3 (FIGURE 1 — chart, pond no. 3). In September it was rather rare, floating and healthy. For the next few weeks there was not much change except that the growth was slightly more abundant ; about November 21 it settled to the bottom and collected around the edges of the pond. At this time a good part appeared unhealthy. On January 5 it had spread out over the bottom of the pond and was dark-green and healthy-looking. It continued to increase in

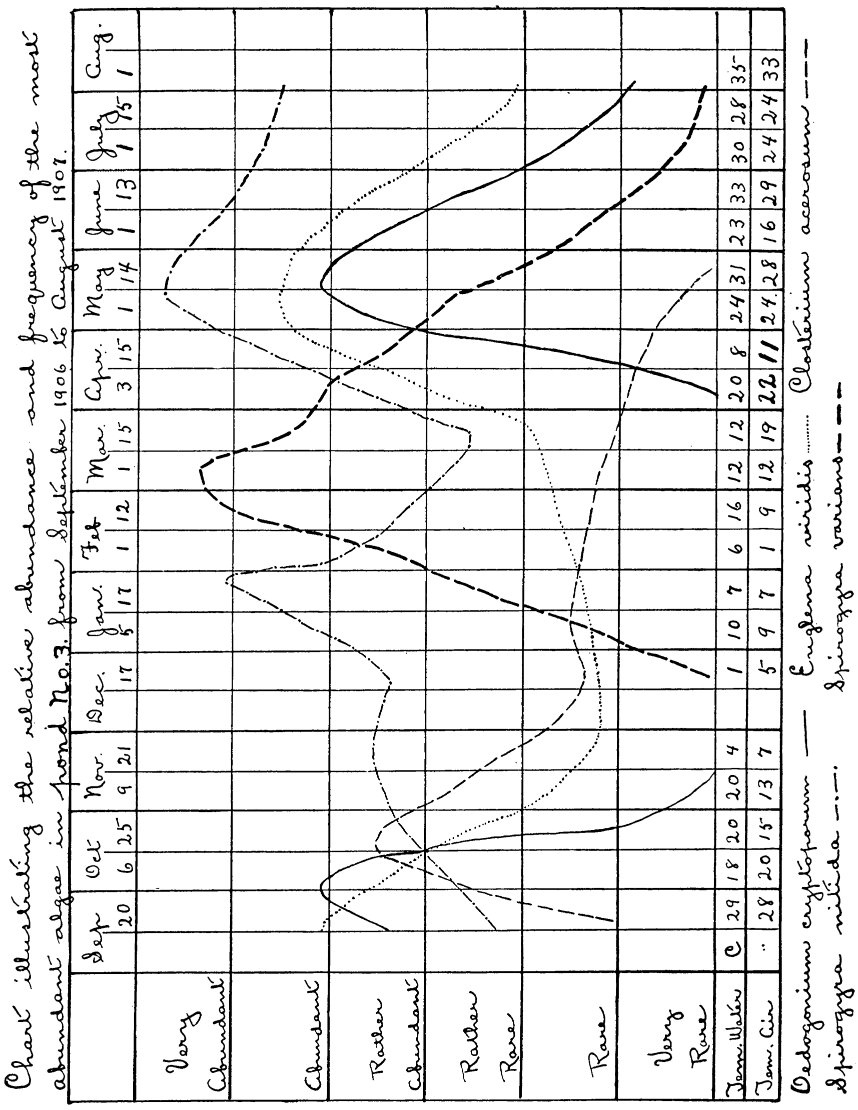

FIGURE I.

abundance during the month of January until toward the last, when it began to become more rare and unhealthy. During February and March, the growth became rather rare and unhealthy but showed no signs of fruiting. During April and May, it became very abundant and thrifty in its growth, and continued to be abundant until the first of August, being the dominant alga in the pond. There was no indication of fruiting during the year; conditions did not become hard enough to check the vegetative growth sufficiently to cause the plant to enter the fruiting stage. The fluctuation in the amount of growth from time to time was doubtless due mainly to change in water supply and temperature. Increased growth followed warm rains.

In pond no. 4 *Spirogyra nitida* appeared for but a short time in October when the pond was low. When rains came, the region was covered with deep water. The alga then disappeared. In pond no. 2, a pond with similar conditions, the growth was similar.

None of this species was found in the water-works reservoir. It does not seem to thrive in large bodies of pure water nor in pure flowing water. It was rather rare in stream no. 1 above the campus during October and November, then disappeared. None at all was found in stream no. 2. It was not observed fruiting at any time during the year.

Of the species of *Spirogyra*, *S. varians* ranked second. It was very abundant during a part of the year in ponds nos. 2and 3 and in similar ponds (FIGURE 1 — chart, pond no. 3). From September to January, this species was rather rare in all the ponds and streams. On January 23 it was found to be very abundant in pools on the ground in open fields in different places where the water had been standing several days. On February 12 it was very abundant in ponds no. 2 and no. 3. It continued to be abundant, in a healthy vegetative condition until the middle of April, when it began to look unhealthy, diminishing considerably in quantity. During February and March, it was near the bottom of the ponds, but when it became unhealthy-looking in April it was floating. It has not been observed to fruit in these ponds. That found in wet-weather pools has been observed to begin conjugation every time the pools start to dry up. After each rainy period conjugation ceased and the plant multiplied rapidly vegetatively until the water began to get low again. This species appeared in stream no. 1 above the campus during October (FIGURE 2—chart, stream no. 1), but

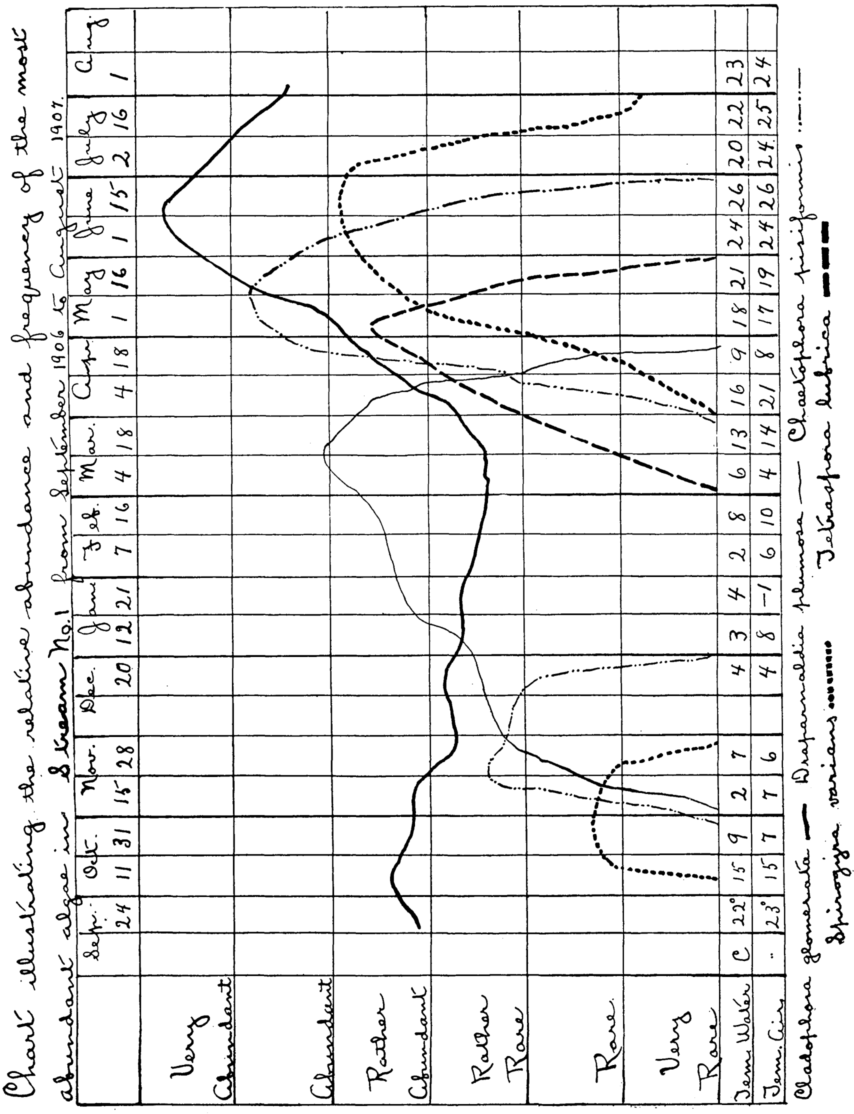

FIGURE 2.

was never very abundant. Some was noticed forming spores on November 15. Spores were formed in cells of the filament without any evidence of conjugation either between cells in the same filament or with cells in another filament. The spores produced resembled zygospores closely. These were likely aplanospores, such as described by West * ('04). None of this species was found after November until about the middle of April, when it became abundant in the upper part of the stream. This was not in a healthy vegetative state. It remained in about the same condition throughout April and early May, not healthy, fruiting to some extent. (Doubtless this that appeared in the stream in April was washed out of a pond farther up the valley.) *S. varians* seems to attain its maximum growth at a temperature considerably lower than that at which *S. nitida* attains its maximum.

Spirogyra crassa was found to be rather abundant in a bayou along the edge of the larger of the water-works ponds during August, 1906. This disappeared with the drying up of the bayou in September, and it has not since appeared. On October 12 the same species was found to be rather abundant in an old bayou along stream no. 1. This bayou is about 10 feet wide, 2 feet deep, and 40 feet long. It has been formed by the "branch" during high water but is not connected with it directly at present. The alga continued to be rather abundant during October and November and in a healthy growing state. In December it became very abundant, spread out over the pond, sank to the bottom, took on a dark-green color and remained very abundant until the first of May. During the winter it did not grow much, although it seemed to be green and healthy. About the first of May, it was not quite so plentiful, nor so healthy as formerly. Later in May, it disappeared altogether. It seemed to become unhealthy and very slimy looking. Just what caused this the writer is not able to state. Possibly a certain amount of sewage or chemicals from the chemical laboratory was washed into the bayou during high water a few days before the disappearance of the alga. The alga was not carried away by the water. It did not conjugate.

Some other species of *Spirogyra* were found at different times but in no great quantities. During December, *S. inflata* was found in limited quantity in one corner of the smaller of the water-works ponds where the water was not very pure. Some decaying vegetation resulting from cormophytic plant growth the previous summer, and the refuse from the pumping station near by, tended to make the water here impure. This was fruiting freely when found and was not found afterward.

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* West, G. S. British Freshwater Algae, 123. 1904.

Spirogyra Weberi was found in the upper part of stream no. 1 in October in very small quantities and it was rather abundant in pond no. 3 during September and October. It became rare the first of November and disappeared later in the month. No conjugation was noticed although it might have taken place in short time and the whole plant growth disappeared, or it might have been so scattering that it was not noticed, the plant not being very abundant. A few other species were found in small quantities but no attempt was made to follow them in their periodicity.

Among the filamentous forms of Conjugatae, *Zygnema* ranked next to *Spirogyra* in abundance and distribution. It was found in some quantity in several of the ponds but not in great abundance in any case. In stream no. 1, *Zygnema insigne* appeared during October, became rather abundant, then gradually disappeared in November. It was not observed to fruit. On April 18, *Zygnema leiospermum* was found in the upper part of the stream just below a pond in which the species had been growing. It was rather rare, not growing or healthy looking, and was fruiting to some extent. This species continued to be present in small quantities until the first of August. The same species was rather abundant in pond no. 3 during the latter part of September, 1906. It was pale-green and unhealthy looking, and mixed with *Spirogyra*. It became rare during October and disappeared the first of November. A few scattering filaments of *Z. leiospermum* were found in pond no. 2 during November, 1906, and also during the following May. *Z. cruciatum* was found to be rather abundant in pond no. 1, March 14. It was not very healthy in appearance and remained in about the same condition until the latter part of May, when it began to grow, became more healthy, and more abundant. It was along the edge of the pond in shallow water — some of it floating. This disappeared in June.

Mougeotia was not very abundant at any time in the waters under observation. A few species were found in limited quantities. *Mesocarpus radicans* was found on April 4 in small quantity in the smaller water-works pond, among a growth of *Typha*. It was not seen there again but was found in a water-trough near by, in which there was flowing water. It was rather rare here during April and May, then disappeared. *Mougeotia scalaris* (*Mesocarpus scalaris*) was found in the upper waters of stream no. 1, October 1. It was rather abundant and unhealthy looking and became more rare and unhealthy the latter part of October and in November. None was noticed after November 15 until March 4, when a small amount was found in an unhealthy condition; it did not seem to be growing any and had doubtless passed the winter in that condition. During May it began to grow and again became rather abundant. Following this it became rare but persisted throughout the summer. Small quantities of *Mougeotia parvula* (*Mesocarpus parvulus*) were found in small pools of water in the upper part of stream no. 1 in May. The water here was slightly stagnant, not flowing freely. This was rather abundant in stagnant pools until the first of August.

Another filamentous form of the Conjugatae found was *Mougeotia genuflexa* (*Pleurocarpus mirabilis*). This was rather abundant in the lower part of stream no. 2 during the latter part of October and in November. Many filaments were bent at nearly right angles and the angles were united as if the cells were conjugating but nothing to indicate the passage of cell contents was observed. No spores were seen. On June 3 this plant was found floating in the upper part of the larger of the water-works ponds, near where it was found in stream no. 2. It was rather abundant and not very healthy and seemed to be in an early stage of conjugation similar to that which was seen in November. Later in the summer, this species was found floating in several places in both of the water-works ponds. In every case certain cells were bent as described above and connected with similar cells in other filaments. The plant always appeared to be unhealthy.

Representatives of six genera of the family Desmidiaceae were found but only a few species in each genus — one in some. *Closterium* appeared to be the most abundant, both in quantity and distribution, appearing in four different ponds. *Closterium acerosum* was especially abundant in pond no. 2. Here it was noticed October 29, rather rare but in a healthy growing condition. It became rather abundant during November and December, then, increasing by cell division, it became very abundant in January. During February and March, the plant began to look somewhat unhealthy and was only rather abundant. During April and the first part of May, it again became healthy, grew rapidly, and became very abundant. Later in May, it began to be rare again. Following this, it became very rare and disappeared in June. In pond no. 3, this form was found during the greater part of the year but never in abundance. There was some fluctuation in amount, becoming rather abundant in November, then rare (FIGURE 1 — chart, pond no. 3).

In the upper part of stream no. 1, *Closterium acerosum* was noticed September 24. It was rather abundant, growing among filaments of *Spirogyra*. It became less plentiful during October and disappeared during November. In every case *C. acerosum* was found growing with *Spirogyra*, either among the filaments or on the bottom. Just what caused the fluctuation in the amount of the plant, is not easy to explain. It was probably not due to temperature, for in one instance when most abundant, in January, the temperature was low, 5° C. and in another, in April, it was rather high, 18° C.; it became rare in February under a low temperature, 1° C., and rare in May under a temperature of 26° C. It is doubtful if the animal life of the pond had any bearing on the matter. There were few small animals in the pond that would likely feed on the desmids. The periods of greatest abundance seemed to follow seasons when the water was lower and more impure. This doubtless had some influence on the growth, for in some experiments, to be mentioned later, it was found that if the liquid in which the desmids were growing became more dense, cell-division would be more frequent.

A few specimens of *Closterium Ehrenbergii* were obtained from pond no. 1 during November and also during May. On May 14 a good quantity of this species was found growing among filaments of *Cladophora* in a large glass jar in the University greenhouse. This material was so rich in desmids that thousands of them could be obtained free from impurities by rinsing a small mass of the *Cladophora* in a small vessel of water a moment or two. After obtaining the desmids in this way, they were placed in a large crystallizing dish in which there was a small amount of *Cladophora* growing. By filling the vessel with water every few days the desmids were kept growing for several months and a careful study was made of them. The vessel was kept in the greenhouse where the air was damp and the temperature moderately high and steady. At certain times these desmids were found to divide so as to reproduce themselves vegetatively much more abundantly than at other times. Different causes seemed to induce this. If the water began to get low in the vessel so as to make the solution more dense and richer in salts, division appeared to be more active; if placed on agar saturated with normal culture-solution, they divided more abundantly; if placed in a small crystallizing dish on the oven, so as to change the temperature suddenly to a relatively high temperature, 26° C., in 48 hours, one half of the number were in the process of division. A sudden change, or hard conditions seemed to induce cell-division. The cells that divided on the agar preparation, and the ones that divided in the vessel on the oven did not develop into two healthy, full-sized specimens; the ones in the vessel kept in the greenhouse required from six to eight days after cell-division could be first noticed for the daughter semi-cells to reach full size.

Experiments similar to the above were tried with *Closterium acerosum*, with similar results.

A very few specimens of *Cosmarium* were present in all the ponds and streams throughout the year, but in no case were they found in any abundance. On April 30 a few *Cosmarium* zygospores were found in pond no. 1. *Docidium Trabecula* was rare in pond no. 3 during October and November, and a few specimens were obtained from pond no. 2, January 14. *Hyalotheca* and *Staurastrum* were present in the spillway of pond no. 4 in very small quantities in December. A few specimens of *Penium interruptum* were found in the lower part of stream no. 1 during June, 1907. This species appeared in the water-works reservoir about the same time.

The Oedogoniales ranked second in abundance, considering quantity, and they were rather generally distributed in the ponds and streams under observation. *Oedogonium* and *Bulbochaete*, representing the two genera in the family Oedogoniaceae, were found, *Oedogonium* being quite common and *Bulbochaete* rather rare.

Oedogonium crassiusculum was abundant and the dominant alga in pond no. 1, September 20 (FIGURE 3—chart, pond no. 1.) It was mostly attached to dead *Typha* stems and other stems under water.

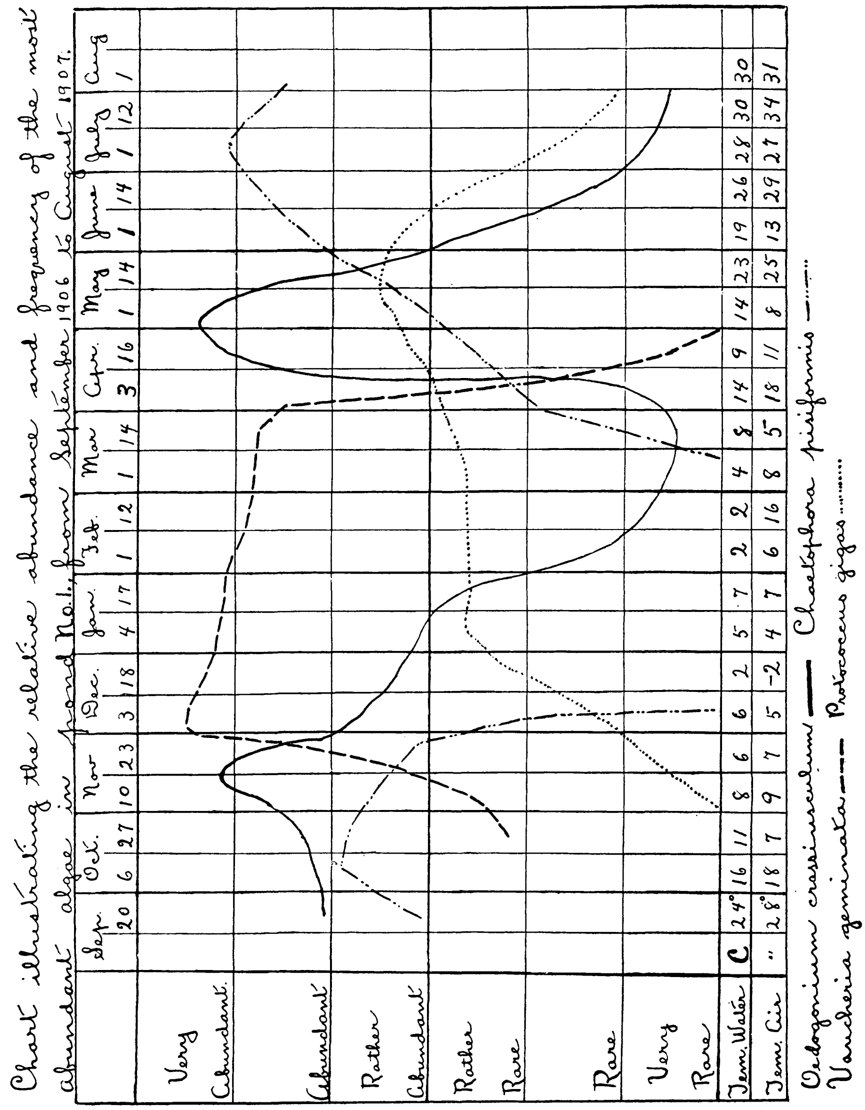

FIGURE 3.

A few filaments were fruiting. It became more abundant during October, continuing to fruit to some extent. In November it became more healthy and thrifty looking and fruiting filaments became rare. During December and January, the plant was rather abundant in sort of a resting state — not growing any, living, but crusty looking, due to particles of soil and diatoms clinging to the filaments. A similar condition continued throughout February and the first half of March, except that the plant became more rare. Between my visits to the pond on March 14 and April 3, considerable change took place. On the latter date there was in the pond a considerable amount of the alga floating in unattached masses. This seemed to be rather healthy looking and was just beginning to fruit sexually, dwarf males being numerous. The warm weather and sunshine of the latter half of March must have caused vigorous growth and as the filaments became older and longer they became free-floating. On April 16 this floating form had become abundant near the surface, especially around the edge of the pond, and the fruiting organs were very abundant. This began to disappear during the latter part of April and by the middle of May had entirely disappeared. The part attached continued to be about the same until the latter part of May, when it became more rare, brownish and not very healthy looking. It remained very rare and unhealthy until August.

This alga did not appear in any of the other streams and ponds under observation except in pond no. 2. It was found to be abundant here October 11 — scattered all over the pond, some attached to *Eleocharis* and *Potamogeton* plants but the most free-floating. The plant became more abundant during the latter part of October and the first part of November. In the latter part of November it became unhealthy looking, less abundant, and settled to the bottom. It disappeared altogether in the first part of December. The floating masses were not observed fruiting. Some few of the attached filaments bore sexual organs. The floating masses appeared here as suddenly as in pond no 1. It disappeared more slowly; the loose, floating masses were mainly washed out of the pond.

Oedogonium cryptoporum appeared in three different ponds, nos. 3 and 4 and the larger of the water-works ponds, but not in much abundance in any one. A small amount was found in September, October, and the first part of November. Later in

November it disappeared, not appearing again until the middle of the following April. It then became rather abundant, reaching its maximum in the first half of May. On May 18 it was fruiting abundantly. About the first of June, it had become very rare in most places, entirely disappearing in some.

The causes of this periodicity of *Oedogonium* are not easy to explain; only a few facts can be pointed out that probably had an influence. The increase in the amount of *Oe. crassiusculum* in November was not very great. Doubtless a good portion of this passed the summer in a sort of resting condition — the filaments growing but little — then, when rains came in November, increasing the amount of water in the pond, there was growth. Following this time, the temperature became too low for much growth and the alga became more rare, yet a relatively small amount persisted throughout the winter in a resting state. When heavy rains came in March, accompanied by warm weather, there was a rapid growth for two or three weeks. As the temperature of the water became higher and the light more intense, the alga was caused to pass from a vegetative to a fruiting state and after fruiting it began to disappear rapidly. Klebs* (1896) found in experimenting with *Oedogonium* that increasing the intensity of light would tend to cause an increase in the production of sexual organs.

Bulbochaete crenulata appeared in pond no. 1 about November 23, and persisted during the winter in small quantity, growing but little. About the first of May, it had become slightly more abundant, was growing somewhat, and bearing sexual organs. Later in May it disappeared. On July 31 a small amount was found attached to grass in the upper end of the larger of the water-works ponds. It was in a vegetative state and did not appear to be growing much.

The Chaetophorales were tolerably abundant in the ponds and streams studied and rather generally distributed, the genera *Chaetophora* and *Draparnaldia* being the most abundant.

Representatives of but two genera were found belonging to the family Ulotrichaceae; these were *Ulothrix* and *Stichococcus*. *Ulothrix aequalis* appeared in pond no. 1 about the middle of

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* Klebs. Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. 1896.

March, growing with *Vaucheria* and not attached. This was rather healthy and growing for a time. It became rather abundant on the east side of the pond during the latter part of April and the first of May. Then it began to become unhealthy looking, the cells of the filaments coming apart. From this time on it gradually disappeared, none being found June 25. *Ulothrix zonata* appeared in the lower part of stream no. 1 the middle of July. It seemed to be healthy and growing, was a bright-green, with filaments a foot or two long, attached at one end, the other floating. It disappeared in a few weeks. A small amount of *Coleochaete scutata* was found in pond no. 1, July 8, clinging to dead submerged *Typha* stems.

A small amount of *Stichococcus* was found growing on the dry clay soil clinging to the roots of a large tree that had blown down along stream no. 2. The soil was sheltered so that it was usually rather dry. This was first noticed early in the winter. It remained in a growing stage during the entire winter, reaching its maximum abundance in March. During the latter part of May and the first of June, it disappeared. Doubtless the soil became too dry and the temperature too warm.

A limited amount of *Herposteiron* was epiphytic on *Oe. crassiusculum* in pond no. 1 during March and April.

Representatives of three genera belonging to the family Chaetophoraceae were found — *Chaetophora, Myxonema,* and *Draparnaldia. Chaetophora* was the most abundant, appearing in considerable quantities in pond no. 1 and stream no. 1 (see charts).

Chaetophora pisiformis was rather abundant in pond no. 1, September 20, 1906, appearing as small glistening greenish globules attached to submerged objects. It continued to be rather abundant until the last of November, when it disappeared; appearing again about the middle of March, it spread over the pond and became very abundant in distribution especially, coating nearly everything submerged in the pond. It continued abundant to the first of August, being the dominant alga of the pond the greater part of the time. The same species appeared in the upper part of stream no. 1, November 15. It was abundant for about a month, attached to sticks, grass, and stones on the bottom of the "branch." The masses here seemed to be much larger than in pond no. 1, as large as a pea, light green and bladder-like. It disappeared the last of December, appearing again the first of April. It became very abundant during the last of April and the first of May — the dominant alga. It began to be more rare the last of May and had entirely disappeared by the last of June. The animal life of the stream doubtless had something to do with its disappearance. There were numerous tadpoles in the "branch" and it was noticed that in pools in which there were many tadpoles there was no *Chaetophora*. The disappearance during the winter was likely due to low temperature.

Chaetophora endiviaefolia was found to be rather abundant, attached to objects on the bottom in the upper part of stream no. 1, November 15, 1906. A little later it became rare, but persisted in small quantities during the winter. In March it began to increase in abundance, becoming very abundant about the middle of April. This continued until about the first of June, when it began to disappear. By the last of June, it had entirely disappeared. This species was doubtless affected by the same agencies as the preceding form.

Draparnaldia plumosa appeared in the upper part of stream no. 1 about the middle of November, 1906 (see chart). It seemed to be healthy and growing. It varied in abundance during the winter, being usually rather rare or rather abundant. Floods washed away large quantities, making it rather rare at times. Material brought into the laboratory on February 16 showed numerous zoöspores in 24 hours. This plant reached its greatest abundance in March. After this it began to disappear and by the last of April had disappeared altogether. This plant appeared in several other places, but in every case the conditions were very similar. It seems to thrive in flowing surface-water at a temperature ranging from 0° to 15° C. In no case was the plant found in a pond.

Two species of *Myxonema* were found, *tenue* and *nanum*. *M. nanum* persisted throughout the year without change on wet rocks at outlet of sewer on campus. The conditions under which it was growing were not subject to much change, the water being warm continually, about the same in amount and always richly laden with sewage. *Myxonema tenue* was first noticed in the lower part of stream no. 1 April 18. The filaments were attached at one end, floating in long ribbons. Material brought into the laboratory produced numerous zoöspores in a few hours. This form persisted until the first of August, becoming rather rare at times.

The only species found belonging to the order Cladophorales was *Cladophora glomerata.* This species was present in the upper part of stream no. 1 (see chart) throughout the year. During only a few months in the spring, ranging from the middle of April to the middle of June, was there much growth. During this time it grew rapidly so as nearly to fill the channel of the stream. Its growth was checked at the end of this time, doubtless by the water becoming low, impure, and warm. During the rest of the year the filaments that persisted were unhealthy looking, the cells had thick walls and were crusty looking, due to particles of sand and diatoms clinging to them. It was noticed in several places that where the plant grew in swift water the filaments were much branched; in quiet flowing water there was but little branching. *Cladophora* was not found in a healthy growing state in any of the ponds. Small masses were found in some, but it was not in a healthy condition and had doubtless floated in from a feeding branch. *Cladophora glomerata* transferred from stream no. 1 to stream no. 2 and anchored in the latter failed to grow. This stream has purer water, flows swiftly and has a relatively lower temperature than the first, standing at about 12° C. continually.

The only representatives of the order Siphonales found in the regions studied were two species of *Vaucheria*, *V. sessilis* and *V. geminata*, var. *racemosa*. *V. sessilis* was very abundant on the damp, sloping banks all around the larger of the water-works ponds October 4. It continued to be abundant and healthy, growing vegetatively until the first of November, when it began to bear sexual organs. It was fruiting considerably the middle of November. On the fourth of December it was looking yellowish, unhealthy, and seemed to be loosened from the ground, due to the ground freezing and thawing. On December 21, the ground was covered with snow, but in places small patches of *Vaucheria* could be seen, unhealthy in appearance. Ripe oöspores were found in it. They were no doubt "seed" for next year's crop. On January 10 the banks were in the main covered with water due to a rise in the pond, and no *Vaucheria* was to be seen. It did not reappear before the close of the study, the first of August.

Vaucheria geminata var. *racemosa* was found in pond no. 1, October 6 (see chart). It was rather rare, growing in shallow water and fruiting somewhat. During the first of November the pond dried up in parts, but the *Vaucheria* continued to grow freely, forming a dense felt over the rich damp earth on the bottom of the pond. On November 23 this was covered with about a foot of water. The submerged *Vaucheria* showed some signs of decay. It remained in about the same condition, unhealthy looking until the twelfth of February, when it was found that the old filaments were covered with fruiting organs. Some of the felts remained attached to the bottom, while others loosened and floated around. They persisted until the last of March, when the filaments turned black and decayed. The pond is surely well sown with spores. The change in conditions due to the flooding with water more than likely caused the formation of the reproductive organs. An aquatic form grew throughout the year in stream no. 2 near the spring. Here there was but little variation in the condition, quantity, or temperature of the water. There was no change in the alga. No sexual organs were produced. This seems to show that under steady favorable conditions an alga continues in a healthy, growing, vegetative state continually. It was not possible to determine the species of this alga.

Numerous representatives of the order Protococcales were found but they were nearly all found only occasionally and in very small quantities. On account of this we will pass by all of them except *Tetraspora* with a mere mention at the end of this sketch. *Tetraspora lubrica* began to appear in the upper part of stream no. 1 the first of March (see chart). It increased in abundance until the first of May, when it reached its maximum. By the end of May, it had disappeared. This alga seems to thrive in "branch"- or surface-water when flowing freely and at a temperature from 5° to 20° C. Certain other colonial forms belonging to the same order, *Gonium*, *Pandorina*, *Pediastrum*, *Coelastrum*, and *Scenedemus*, appeared in the more stagnant pools of the upper part of stream no. 1 during June and July, 1907.

A number of species of Bacillariales were observed but no effort was made to classify them or trace their periodicity.

The Cyanophyceae were not very plentiful in the regions studied except in two places, the smaller of the water-works ponds and in the lower part of stream no. 1. This class of plants seems to thrive best in impure water. The water-works pond just mentioned, taken as a whole, contains relatively pure water, but at one corner near the pumping station it was very impure, due to the oil and refuse from the pumping station flowing into it. Here there was always a good amount of the Cyanophyceae to be found growing. From this place they floated out and settled around the edge of the whole pond.

Two species of *Nostoc* appeared in the territory studied, *N. verrucosum* and *N. commune*. *N. verrucosum* persisted throughout the year in stream no. 1 with very little change. At times it appeared to be less abundant but this was due to the water washing away a part during floods. It was attached to the stone bottom of the "branch" in the swifter parts. It grew up in hollow subglobular masses five or six centimeters in diameter. They were at first pale yellowish-green, rather firm, jelly-like masses, but the outer part soon became incrusted with lime so as to make it harsh and crusty. Soon after reaching this stage the flow of the water caused them to break loose and float away. No heterocysts or spores were noticed.

A small amount of *N. commune* was found growing on the damp soil along the edge of pond no. 3, September 20, 1906. The region was covered with water at my next visit and none of the alga was found. The same species was found growing in a similar place along the upper part of stream no. 1, October 11. It continued to grow here and was rather abundant until the middle of November, when it disappeared.

Scattering filaments of *Anabaena* were found at various times during the year in material collected in the lower part of stream no. 1, pond no. 1 and the smaller of the water-works ponds, but no attempt was made to trace the periodicity.

Three different species of *Oscillatoria* appeared in considerable abundance in the ponds and streams under observation. These were *Oscillatoria tenuis*, *O. limosa* and *O. princeps*. Some other species were noticed but they did not persist any length of time. *O. tenuis* was the most abundant form both in quantity and distribution. It was abundant in stream no. 1, especially in the lower part, and in the smaller of the water-works ponds during the greater part of the year. In stream no. 1 it grew on the stones in the bottom, forming a tolerably dense stratum. A similar stratum formed on the rocks at the outlet of pond no. 4 whenever sufficient water flowed over the spillway to keep them wet. Around the edge of the smaller of the water-works ponds there was usually a stratum covering the bottom in the shallow water. Whenever sufficient oxygen collected in the meshes of a mass it was loosened and floated on the surface.

Oscillatoria princeps (*O. Imperator* Wood) was found to be rather abundant in the most stagnant part of the smaller of the water-works ponds during the latter part of September, October, and the first of November, 1906. It appeared again the first of June, 1907, and continued to be rather abundant until August. It appeared also in ponds nos. 2 and 3, going through a similar periodicity.

Oscillatoria limosa (*O. Froelichii* Kütz.) appeared in all the ponds and streams except pond no. 1 and stream no. 2, being especially abundant in pond no. 2 and stream no. 1 from December to the first of May. It seems to thrive well in foul water. It seemed to become more abundant in pond no. 2 when there was considerable cow-manure around the edge of the pond. Cattle had access to the pond only a part of the time.

Calothrix parietina (*Isactis caespitosa* Wolle) was abundant on the stones in the bottom of stream no. 2 the entire year, changing but very little. The conditions under which it grew were unchangeable.

CONCLUSIONS *

An alga growing under steady normal conditions continues, in the region studied, to grow in a healthy vegetative state throughout the year. *Nostoc verrucosum*, *Calothrix parietina*, and the *Vaucheria* growing in stream no. 2 showed this, and also the *Myxonema nanum*, growing at the sewer outlet.

A sudden change in external conditions checks the vegetative growth of an alga and tends to cause it to enter a resting stage form or to fruit sexually.

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* For local observers I may state that stream no. 1 is known as Jordan Branch; stream no. 2, Stone Spring Branch; pond no. 1, Hill Pond; pond no. 2, Faris Pond; pond no. 3, Fees Pond; pond no. 4, Monon Pond.

Spirogyra varians is the most widely distributed alga found in this region. It grows under varied conditions. It conjugates at all seasons of the year, depending on hard external conditions, *e. g.*, the drying up of a pond.

Chaetophora thrives best in water slightly stagnant at a temperature from 5° C. to 25° C.

Draparnaldia plumosa thrives in flowing surface-water at a temperature from 1° to 15° C.

Cladophora glomerata grows best in flowing surface-water. It persists throughout the year in the locality studied but is in a growing condition only a few weeks in the spring, while there is a brisk flow of moderately pure water.

Spirogyra nitida is the most abundant of the Conjugatae in the small stagnant ponds about Bloomington.

A CLASSIFIED LIST OF THE ALGAE FOUND, TOGETHER WITH BRIEF DATA ON THE FORMS NOT DISCUSSED ABOVE

CHLOROPHYCEAE

CONJUGATAE

Zygnemaceae

- *Spirogyra* Link
    - *nitida* (Dillw.) Link
    - *crassa* Kütz.
    - *varians* (Hass.) Kütz.
    - *neglecta* (Hass.) Kütz. Bayou along lower part of stream no. 1, 11 Je to 1 Au '07.
    - *Weberi* Kütz.
    - *inflata* (Vauch.) Rabenh.
    - *rivularis* Rabenh. Water-works reservoir, 29 Je '07.
- *Zygnema* Kütz.
    - *insigne* Kütz.
    - *leiospermum* De Bary
    - *cruciatum* Ag.
- *Mougeotia* De Bary
    - *genuflexa* (Dillw.) Ag. (*Pleurocarpus mirabilis* A. Br.)
    - *scalaris* Hass.
    - *parvula* Hass.

Desmidiaceae

- *Closterium* Nitsche
  - *Cucumis* Ehrenb. Upper part stream no. 1, 27 Je '07.
  - *acerosum* (Schrank) Ehrenb.
  - *strigosum* Bréb. Pond no. 1, 14 My '07.
  - *Dianae* Ehrenb. Pond no. 1, 15 N '06 to 10 F '07.
  - *Ehrenbergii* Menegh.
- *Cosmarium* Corda
  - *Botrytis* Menegh. Pond no. 2, 23 N '06 to 25 Jl '07.
  - *laeve* Rabenh. Pond no. 3, 20 S '06.
  - *pyramidatum* Bréb. Water-works reservoir, 10 D '06.
  - *Phaseolus* Bréb. Pond no. 4, 8 D '06.
- *Docidium* Bréb.
  - *Trabecula* (Ehrenb.) Naeg.
- *Hyalotheca* Ehrenb. sp.
- *Staurastrum* Meyen, sp.
- *Penium* Bréb.
  - *interruptum* Bréb.

OEDOGONIALES

Oedogoniaceae

- *Oedogonium* Link
  - *crassiusculum* Wittr.
  - *cryptoporum* Wittr.
- *Bulbochaete* Ag.
  - *crenulata* Pringsh.

CHAETOPHORALES

Herposteiraceae

- *Herposteiron* Naeg. sp.

Coleochaetaceae

- *Coleochaete* Bréb.
  - *scutata* Bréb.

Ulotrichaceae

Ulothrix Kütz.

aequalis Kütz.

subtilis Kütz. Stream no. 1, 1 My '07.

zonata (W. & M.) Aresch.

Stichococcus Naeg. sp.

Chaetophoraceae

Chaetophora Schrank

pisiformis (Roth) Ag.

endiviaefolia Ag.

Myxonema Fries

nanum (Dillw.) Hazen

tenue (Ag.) Rabenh.

Draparnaldia Bory

plumosa (Vauch.) Ag.

CLADOPHORALES

Cladophoraceae

Cladophora Kütz.

glomerata (L.) Kütz.

SIPHONALES

Vaucheriaceae

Vaucheria DC.

sessilis (Vauch.) DC.

geminata (Vauch.) DC.

PROTOCOCCALES

Volvocaceae

Gonium Müll.

pectorale Müll. Stream no. 1, 10 Je '07.

Pandorina Bory

Morum (Müll.) Bory. Stream no. 1, 10 Je '07.

Pleurococcaceae

Pleurococcus Menegh.

vulgaris Menegh.

Hydrodictyaceae

Pediastrum Meyen

Boryanum (Turp.) Menegh. Stream no. 4, 10 Je '07.

Protococcaceae

Coelastrum Naeg.
  microporum Naeg.
Scenedesmus Meyen
  caudatus Corda. 20 Jl '07.
  obtusus Meyen. Pond no. 4, 4 D '06.
Nephrocytium Naeg.
  Agardhianum Naeg. Upper part stream no. 1, 27 Je '07.

Palmellaceae

Tetraspora Link
  lubrica (Roth) Ag.
Gloecystis Ag.
  gigas (Kütz) Lagerh. Pond no. 1, N '06 to Au '07.

HETEROKONTAE

CONVERVALES

Tribonemaceae

Ophiocytium Naeg.
  bicuspidatum (Borge) Lemm. Pond no. 1, 30 Ap '07.

CYANOPHYCEAE

Nostocaceae

Nostoc Vauch.
  verrucosum Vauch.
  commune Vauch.
Anabaena Bory, sp.

Oscillatoriaceae

Lyngbya Ag.
  ochracea (Roth) Thur. Edge of water-works reservoir, 2 N '06.
  Juliana Menegh.
Oscillatoria Vauch.
  tenuis Ag.
  limosa (Roth) Ag.
  princeps Vauch.

Phormidium Kütz.

tenue (Menegh.) Gom. Edge of pond no. 2, 14 My to 26 J '07.

incrustatum cataractorum (Naeg.) Gom. Upper part of stream no. 1, 5 Mr '07 to 1 Au '07.

Arthrospira Stizenb.

Jenneri (Kütz.) Stizenb. Edge of pond no. 4, 29 Je '07.

Rivulariaceae

Calothrix parietina (Naeg.) Thur. (*Isactis caespitosa* Wolle.)

Chroococcaceae

Merismopedia Meyen

convoluta Bréb. Pond no. 2, 27 F '07.

INDIANA UNIVERSITY, BLOOMINGTON,
INDIANA, August 1, 1907.